shells and burrow fillings. Shales of the La Pena Formation accumulated as still deeper water (environment 3) caused bypassing to cease.

At the type section of the Exshaw Formation on Jura Creek, Alberta, beds of the uppermost Palliser Formation accumulated on a shallow-marine carbonate bank (environment 1). These are overlain abruptly by a 2 to 7 cm sandy bed bearing collophane, bone fragments, and abundant pyrite. This bed may have accumulated in turbid, deeper water (environment 2) during bypassing of finer grained sediment. Further deepening of water resulted in decreased currents, and the black shale of the Exshaw Formation accumulated (environment 3).

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Geology on the Continental Scale: The Decade of North American Geology

No abstract.

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Early Cretaceous Edmonton Channel in Alberta

The Edmonton channel forms part of an extensive Early Cretaceous drainage system on the Alberta plains. Local topographic relief in excess of 160 m was infilled by the Lower Cretaceous Mannville Group. The pre-Mannville unconformity juxtaposes Lower Cretaceous strata on Devonian, Mississippian, Jurassic, and possibly earlier Cretaceous sediments. Erosion was prevalent over sedimentation between the Pennsylvanian and Early Cretaceous Periods, a time of about 150 m.y. This ultimately produced a broad, low-relief alluvial plain with a southwestern dip, blanketed by easterly derived quartzose sandstones.

A prominent lowering of sea level, possibly associated with a worldwide eustatic sea-level fall at about 130 m.y., caused widespread erosion and dissection of the alluvial plain. The north-south oriented Edmonton channel was cut at this time, incorporating elements of an earlier drainage pattern. Flow was to the south and then west to join the Spirit River system which flowed northwest subparallel to the Columbian orogenic belt.

Southward transgression of the sea in Aptian(?)-Albian time led to lowering of stream gradients, deposition of coarser bed load where available, and inundation of the previously established drainage system. The Edmonton channel became a small adjacent sea with somewhat restricted circulation to the main seaway during its early infilling. Numerous estuaries formed in tributaries to the main channel. Sedimentology and paleontology of the Lower Mannville Group sediments in the Edmonton channel indicate deposition is a standing body of brackish water directly upon, or only slightly above, the unconformity. Sedimentation associated with continuing transgression and a subsequent regression accounted for most of the infilling of the Edmonton channel. Local lithostratigraphic nomenclature does not adequately reflect the nature and complexities observed in this sedimentary sequence.

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Application of Computer Graphics to Coal Geology and Coal-Resource-Assessment Studies, Canyon Coal Bed, Birney 1° Sheet, Montana

The National Coal Resources Data System (NCRDS) of the U.S. Geological Survey has the capability through spatial data bases and computer software to depict coal geology and calculate coal resources by computer. The Birney 1:100,000 map in southeastern Montana and the Canyon coal bed were selected to demonstrate this capability. The Birney quadrangle includes parts of Big Horn, Rosebud, and Powder River Counties. Other political entities are the Northern Cheyenne Indian Reservation and the Custer National Forest. The Canyon coal bed locally splits into an upper and lower unit, whose thicknesses range from 1/3 to 33 ft (0.1 to 10 m).

The desired data subset retrieved from the stratigraphic (USTRAT) data base consists of more than 300 drill-hole and 100 outcrop locations and their respective Canyon coal stratigraphic sections. Required digitized information included: X-Y locations (lat. and long.) for each point, township-range intersections, county, and national forest boundaries from the base map, the Indian reservation boundary, the Canyon bed outcrop, and the 200, 400, and 1,000 ft (61, 122, and 305 m) overburden isolines as drafted by the geologist.

GARNET, a NCRDS interactive graphics program, produces isopachs and structure maps, does trend analysis, and allows the user to edit data points, expand areas of interest, and calculate coal-resource areas and tonnages for any defined area. The USGS methodology for calculating and reporting coal resources requires that computations be delimited by criteria of coal thickness, overburden thickness, rank, and distance from points of observation as related to land classification and political subdivisions. GARNET allows interactive graphic combination of digitized and computer-derived lines to produce boundaries of these categories.

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Coralline and Associated Carbonates from Florida Bank (Pliocene), Lee and Collier Counties, Florida

Forty-five rock cores have defined a north-south-trending coralline limestone on the middle of the Florida platform. This is the only known Pliocene bank reef in the Caribbean and differs from Pliocene and Holocene shelf-edge reefs. This bank reef differs from shelf-edge reefs in that (1) its dimensions are smaller, having a maximum thickness of 6 m; (2) pycnodont oyster and molluscan packstones dominate the interreef beds; (3) marine muds are not as abundant; (4) the number of subaerial discontinuities and associated calcitic muds are greater; and (5) dolomitization is not as extensive and appears to be restricted to the oyster facies.

Coralline limestones have been interpreted as boundstones, bioclastic packstones, and monospecific bafflestones. Coralline boundstones usually are divided into two growth episodes separated by calcitic mudstones or subaerial laminated crusts. Oysters and molluscan-rich limestones commonly display current sorting and packing and fining-upward sequences that may be analogous to Holocene sequences associated with sea grasses and/or storm deposits. Environmental information derived from fossils and texture indicates shallow to moderate water depths and moderate energy conditions with sporadic storm events.

Detailed petrographic analysis has identified products of marine, mixing, and freshwater phreatic and vadose diagenetic environments associated with transgressive-regressive cycles related to glaciation. Studied limestones range from 6 m above to 14 m below present sea level in elevation and therefore have been subjected to repeated changing conditions. A complete record of the diagenetic history is lacking in any single rock because of dissolution processes or early tight cementation.

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Lithofacies, Diagenesis, and Porosity, Ivishak Sandstone, Prudhoe Bay Area, Alaska

The Permo-Triassic Ivishak Sandstone is the main reservoir interval of the Prudhoe Bay field, North Slope, Alaska. Studies of cored sequences from the field and offshore (Reindeer Island) reveal that porosity development within the Ivishak Sandstone has a complex relationship dependent on both depositional (lithofacies) and postdepositional (diagenetic) history. These factors are related to the tectonic history of the basin.

Five dominant lithofacies are identified: (1) interbedded very fine sandstones and mudstones, (2) parallel laminated carbonaceous fine sandstones, (3) multistory upward-fining medium sandstones, (4) conglomerates, and (5) multistory upward-fining coarse to granular sandstones. These lithofacies occur everywhere as upward-coarsening to conglomerate sequences. In the onshore (Prudhoe Bay field) area the coarsening sequence is overlain by a gross upward-fining sequence of gravelly to medium-grained multistory sandstones. This thins dramatically to the north, and is absent at Reindeer Island. Consideration of lithofacies and thickness variation leads to an interpretative model concerning evolution of the basin with respect to tectonics and sedimentation. Thus initial progradation of an active alluvial fan-delta system from the northeast was replaced by progressive transgression from the south of more distal upon proximal facies.

Petrographic characteristics of the rocks reveal that porosity development is intimately related to lithofacies. Porosity within the medium-grained sandstones is predominantly due to dissolution of early nodular calcite. Porosity within the conglomeratic intervals appears to be much more of a primary (textural) origin.

Hypothetical porosity profiles can thus be constructed based on predicted lithofacies distribution across the area in any direction.

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Deposition and Diagenesis of Glauconite Sandstone, Berrymore-Lobstick-Bigoray Area, South-Central Alberta

The depositional environments of the Glauconite sandstone in the Berrymore-Lobstick-Bigoray area are distributary channels, delta platform, distributary mouth bars, and interdistributary bays.

The diagenetic mineralogy is consistent with the formation water chemistry. A simplified model for evolution of Glauconite sandstone water compositions includes (1) original derivation in a deltaic setting giving composition of early pore waters as brackish to normal marine, (2) alteration due to inorganic and organic chemical diagenesis, and (3) dilution through time due to meteoric water recharge. The formation waters now evolved have such a composition as to be (1) oversaturated with respect to hematite, kaolinite, and illite (late-stage cements); and (2) near equilibrium to undersaturated with respect to quartz, calcite, siderite, and dolomite.

The early diagenetic mineralogy is a function of early pore waters and thus the subenvironment. For example, ankerite cement forms early at the base of distributary channels.

The intermediate to late diagenetic cementation is a function of early diagenetic mineralogy. For example, hematite is formed by the oxidation of siderite due to meteoric water recharge. Oxidation of pyrite is quantitatively unimportant. Occurrence of late stage hematite is associated with structural highs which are most affected by meteoric water recharge.

Delta platform deposits contain gas, and distributary channel and distributary mouth bar deposits contain water. Delta platform deposits are isolated from distributary channel and distributary mouth bar deposits by a vertical permeability barrier of ankerite cement and a lateral permeability barrier of siderite and kaolinite cement, respectively.

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Subsurface Paleoenvironmental Analysis of Gas-Producing Medina Group (Lower Silurian), Chautauqua County, New York

A paleoenvironmental interpretation of the gas-producing Medina Group from the subsurface of Chautauqua County, New York, was made by making a lithologic study of a core from Panama, New York, and analyzing over 140 gamma-ray well logs. The oldest formation, the Whirlpool, is a light gray sandstone interbedded with thin lenses of siltstone. Isopach patterns reveal that the Whirlpool Formation was deposited in elongate parallel thick areas trending NE-SW which are similar to the patterns produced by modern tidal current ridges. The Whirlpool Formation is interpreted to be deposited as a tidally influenced sublittoral sheet sandstone. The Power Glen Formation is a medium dark gray shale interbedded with a light gray siltstone. It is interpreted as being deposited in: (1) a marine shelf and prodelta environment; and (2) as distal bar deposits. The Grimsby Formation has a light gray basal sandstone followed by medium red sandstone and interbedded with blackish red shales. The isopach patterns indicate that it was deposited in elongated dendritic areas that trend nearly north-south. The Grimsby is interpreted as a tidal-dominated delta, analogous to the modern Ord River delta of western Australia. There are four subenvironments: (1) channel and distributary mouth bars, (2) overbank splay deposits, (3) tidal channel, and (4) tidal flat. A regional correlation was made with the northeastern Ohio White Clinton sands to the basal light gray section of the subsurface Grimsby of northwestern Pennsylvania and Chautauqua County, New York. The Red Clinton of Ohio is correlated with the upper sections of the subsurface Grimsby.

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Temperature Anomalies Associated with Rocky Mountain Oil and Gas Fields

Over the years, a number of observers have reported on temperature observations which show a particular oil or gas field to be "hotter" at the pay depths than the surrounding rock at the same depth. Our study of 22 oil and gas fields from six states in the Rocky Mountain region demonstrates that at least 15 of these fields have positive temperature gradient anomalies at the pay level. Nine of these "hot" fields are contained in structural traps and six are primarily stratigraphic accumulations. Three of them are gas and 12 are oil fields.

All of our temperature measurements were recorded during drill-stem tests except for a few values taken from temperature logs. Drill-stem test temperatures usually are recorded a longer time after mud circulation has ceased in the well bore than are wire-line log temperatures. Therefore, the former generally are a truer measure of the formation equilibrium temperature than are the latter.

Speculating on the causes of these temperature anomalies over oil and gas fields, we conclude that upward fluid movements at depth is the most important factor. The upward-moving fluids carry heat along with them, and both heat and fluids are trapped whenever suitable trapping conditions are encountered in the reservoir rocks through which the fluids pass. The main evidence for this conclusion is the fact that observed temperature